Space Weather Technical Forecast

Issued on Saturday, 31 December 2022 at 12:43 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of further M-flares throughout. Chance of Active High Energy Electron Fluence by day 2 (1st). Possible glancing blow from a CME late on Day 4 (3rd Jan) or more likely into the 4th Jan.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity has been Moderate in the past 24 hours with two M-flares, both originating from AR3176, and the largest of which was an M3 flare at 30/1938 UTC. There are currently five numbered active regions on the visible disc, the largest of which is AR3176 (Eao/Beta-gamma) in the northeast quadrant. The other most noteworthy regions are AR3180 which continues to emerge from around the northeast limb, and has been analysed as a Dao/Beta at present. AR3179 (Dao/Beta), located in the northwest quadrant, which continues to show some growth, but has been relatively inactive; and AR3177 (Dsi/Beta) in the southeast quadrant, which is a moderately large group showing some slight growth, again largely inactive at present.

Coronagraph imagery from STEREO-A imagery indicates a CME was associated with the M1 flare at 30/1528 UTC from AR3176, which has now been analysed and shows a possible glancing blow at Earth either late on the 3rd Jan (Day 4) or early on the 4th Jan (beyond our current forecast period), although with low confidence.

Solar Wind / Geomagnetic Activity: Solar winds, as observed by ACE and DSCOVR were indicative of coronal hole connection, rising rather erratically from around 500km/s and peaking at around 600km/s. Solar winds currently remain elevated near 530km/s and show a gradual declining trend. The density was near average. Total Interplanetary Magnetic Field (IMF), Bt, was at mostly Moderate levels, with a peak around 12nT, but has now dropped to weak levels. The north-south component, Bz, was often negative and fluctuated between +/-10 nT, but has now become less disturbed. Phi angle was predominantly positive (away from the Sun). Geomagnetic activity was mostly Unsettled to Active (Kp 3-4), has recently become Quiet (Kp 2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at background levels. High energy electron flux (greater than 2MeV) was at mostly Moderate to High levels, with a peak of 3680pfu at 30/1510 UTC. The 24-hour integrated electron fluence remained below the Active threshold on a mostly steady trend. The observed fluence at 31/0000 UTC was 7.42e7 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with an ongoing daily chance of M-flares. There is a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: A coronal mass ejection (CME) which was observed in coronagraph imagery, associated with the M1 flare at 30/1528 UTC from AR3176, has now been analysed and shows a possible glancing blow at Earth either late on the 3rd Jan (Day 4) or early

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on the 4th Jan (just beyond the current forecast period). No other Earth directed CMEs were observed. The ongoing coronal hole influence is expected to continue on day 1 (31st), before gradually declining days 2 and 3 (1st and 2nd). No further coronal hole enhancements are expected during the forecast period. Geomagnetic activity is expected to be mostly Quiet to Unsettled, with a chance of an Active interval, as HSS begins to wane over the coming days. Mostly Quiet conditions likely days 3 and 4 (2nd and 3rd Jan), although with a possible glancing blow from a CME late on Day 4 (3rd Jan) which may enhance geomagnetic activity, although this is low confidence.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES-16 is expected to remain at Background levels throughout but with a chance of rising alongside any notable flares, giving a very slight chance of exceeding the S1/Minor Storm threshold. High energy electron flux (greater than 2MeV) observed by GOES-16 is likely to be Moderate to High levels, with a probable upward trend over the next couple of days. The associated 24 hour fluence will then respond, likely approaching/exceeding the Active (1e8 integrated pfu) threshold days 2 and 3 (1st and 2nd), with a chance of rising above this level by the end of day 1 (31st).

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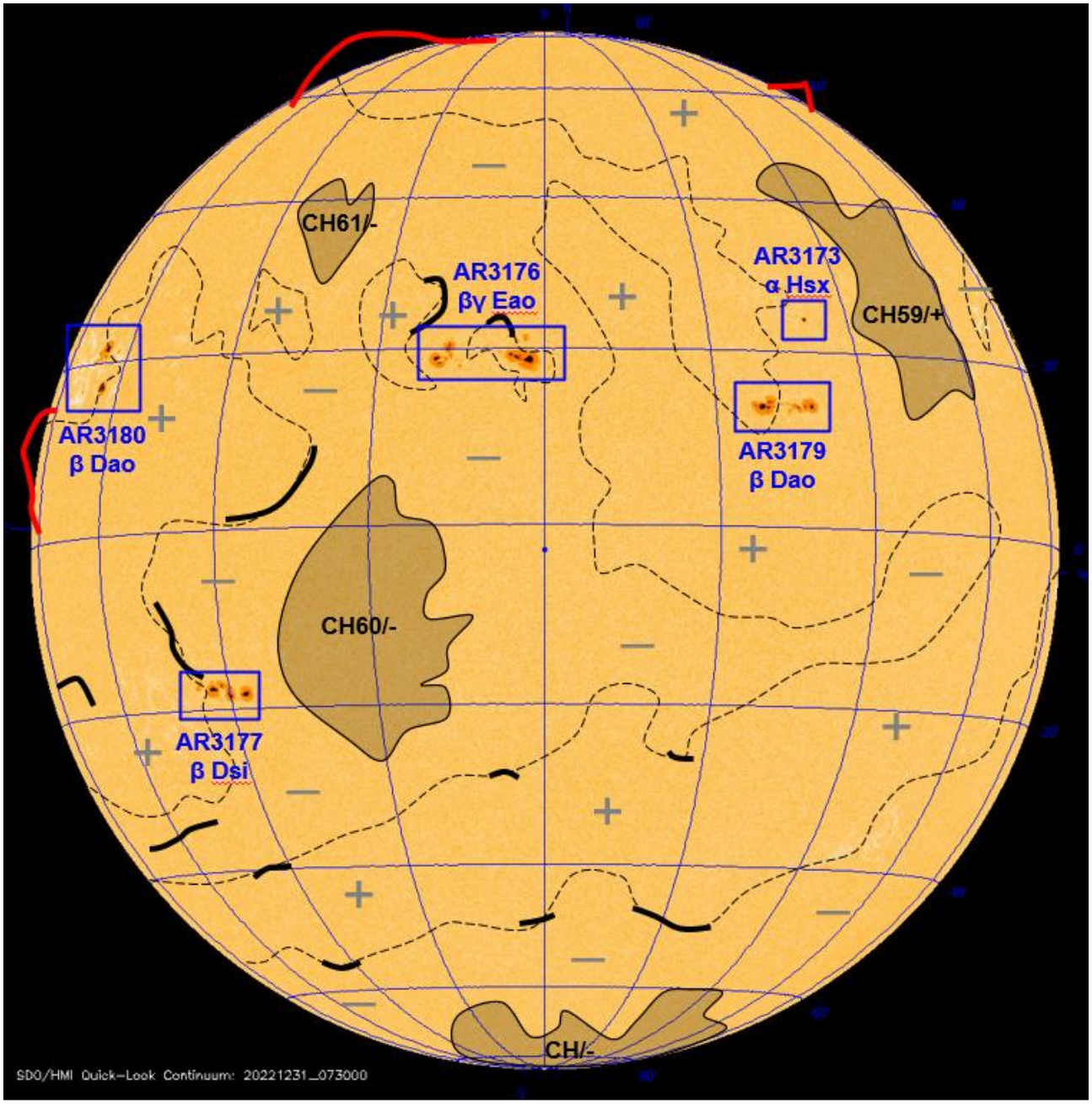
Figure 1. Solar Analysis Valid 31/0730 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A coronal mass ejection (CME) observed in coronagraph imagery associated with the M1 flare at 30/1528 UTC from AR3176, has been analysed. The data suggests a possible glancing blow from the CME at Earth either late on the 3rd Jan (Day 4) or early on the 4th Jan (which is just beyond the current forecast period). However, this a low confidence forecast due to the limited (gaps) data available in the coronagraph imagery. A further analysis may be required to firm up on the details, as and when the imagery becomes more complete. Otherwise, no other Earth directed CMEs have been observed in the past 24 hours.

Solar winds are elevated following connection with CH59/+, this may have also been enhanced by a glancing influence from a CME which left the Sun on the 25th, and was expected to pass ahead of the Earth on the 29th. The ongoing coronal hole influence is expected to continue on day 1 (31st), before gradually declining days 2 and 3 (1st and 2nd), with good confidence for MOSWOC enlil expectations. No further coronal hole enhancements are expected during the forecast period.

Geomagnetic activity is expected to be mostly Quiet to Unsettled (Kp 2-3) on day 1 (31st Dec), with a slight chance of an Active (Kp 4) interval, due to the on-going HSS from a coronal hole (CH59/+). Becoming mostly Quiet from day 2 (1st Jan), but with a slight chance of an enhancement in geomagnetic activity late on day 4 (3rd Jan) with a possible glancing blow from a CME - low confidence.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	5	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Possible glancing blow from a CME which left the Sun on the 30th Dec, which was associated with an M1 flare originating from AR3176 in the northeast quadrant. See ENLIL below. Otherwise, no other Earth-directed CMEs have been observed.

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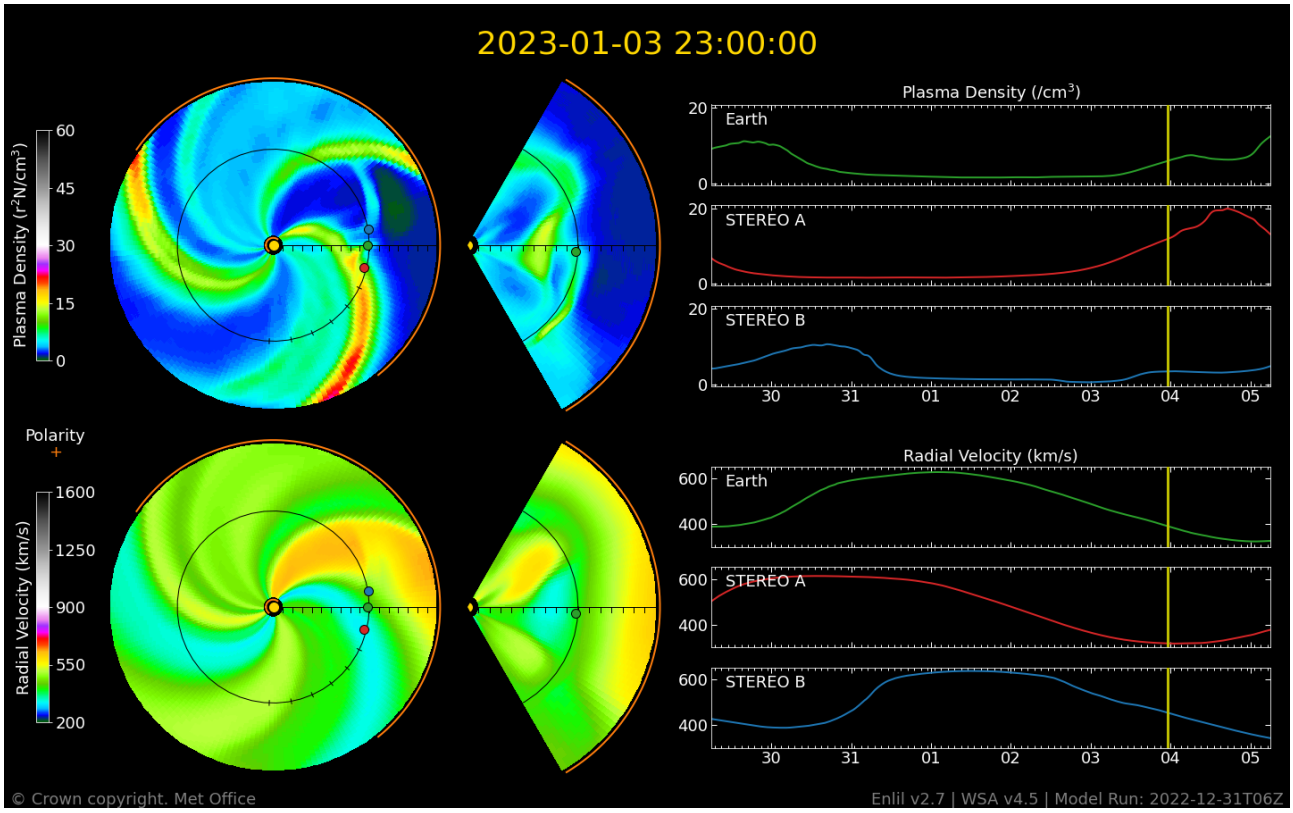
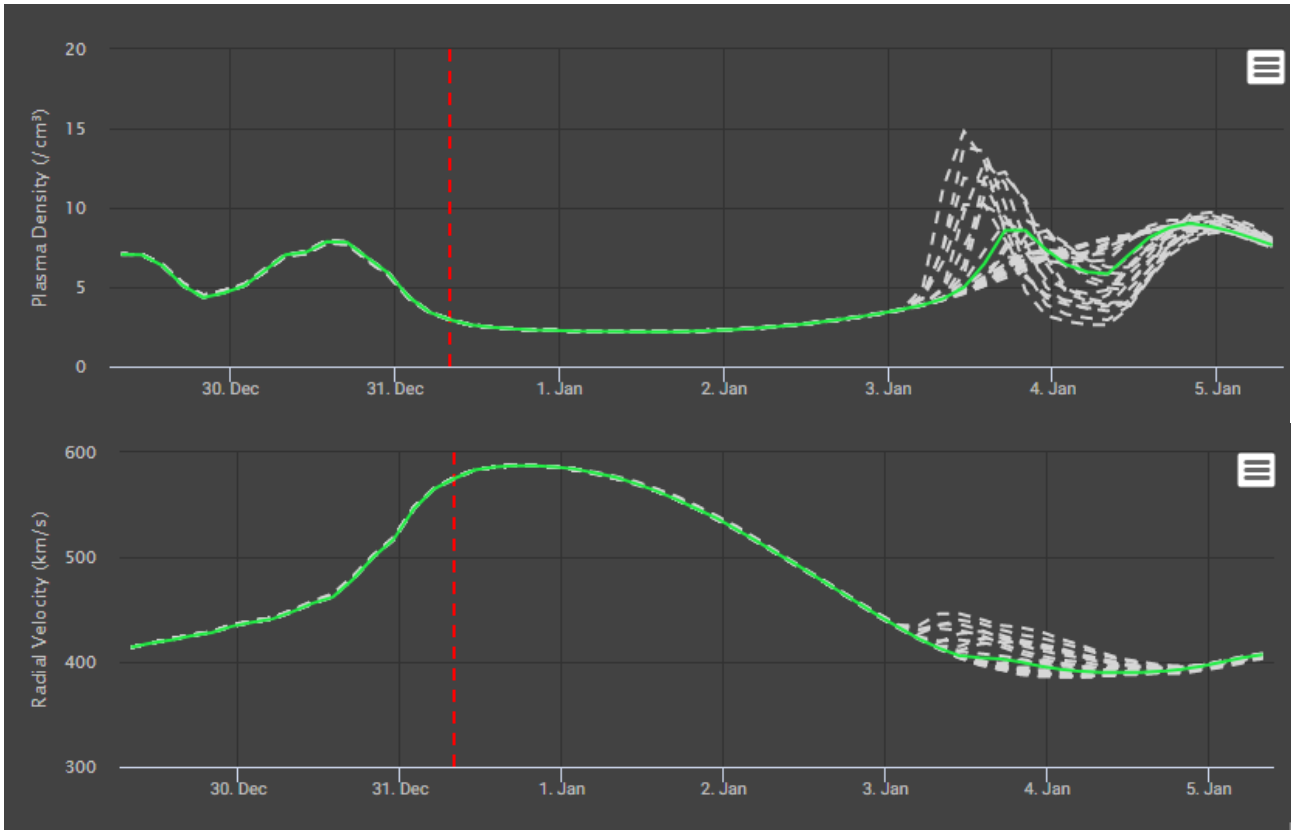
Figure 2: ENLIL and its ensemble (below) shows a possible glancing blow from a CME probably late on day 4 (3rd Jan) – although this is low confidence.





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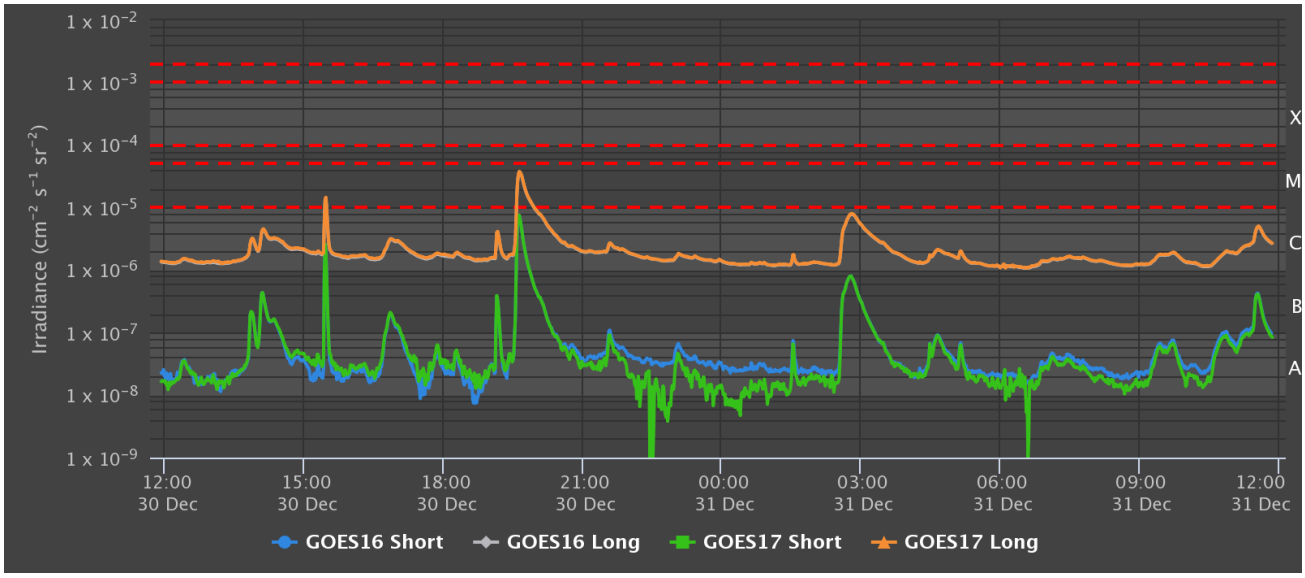
Radio Blackouts - X-Ray Flares:
Solar Activity has been Moderate in the past 24 hours with two M-flares, both originating from AR3176, and the largest of which was an M3 flare at 30/1838 UTC. There are currently 5 numbered active regions on the visible disc, the largest of which is AR3176 (Eao/Beta-gamma) in the northeast quadrant. The other most noteworthy regions are AR3180 which continues to emerge around the northeast limb, and has been analysed as Dao/Beta at present. AR3179 (Dao/Beta), located in the northwest quadrant and which continues to show growth, but has been relatively inactive; and AR3177 (Dsi/Beta) in the southeast quadrant, which is a moderately large group showing some slight growth, again largely inactive at present.

Ex-regions 3160 and 3165 may also return around the eastern horizon in the next couple of days.

Solar Activity is expected to be Moderate to Low with an ongoing chance of M-flares and a very slight chance of X-flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	50	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES X-Ray flares – shows a couple of M-class flares orginating from AR3176 over the last 24 hours.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) measured by GOES-16 is at Background levels. Any significant flares will bring a risk of proton flux rising at points during the period, with a slight chance of exceeding the S1/Minor Storm threshold.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	5	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux as observed by GOES-16 was at mostly Moderate to High levels, with a peak of 3680pfu at 30/1510 UTC. Flux is likely to trend upwards through days 1 and 2 (31st and 1st), perhaps becoming predominately High for a time before gradually subsiding later in the period.

The associated 24 hour fluence is expected to rise in response, approaching, and likely exceeding the Active (1e8 integrated pfu) threshold on days 2 and 3 (1st and 2nd), with a chance of rising above this level by the end of day 1 (31st). REFM has yet to respond to the recent fast wind enhancement, so is currently giving poor guidance to expected fluence.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ 2 MeV ≥ $1x10^8$	No	40	60	50	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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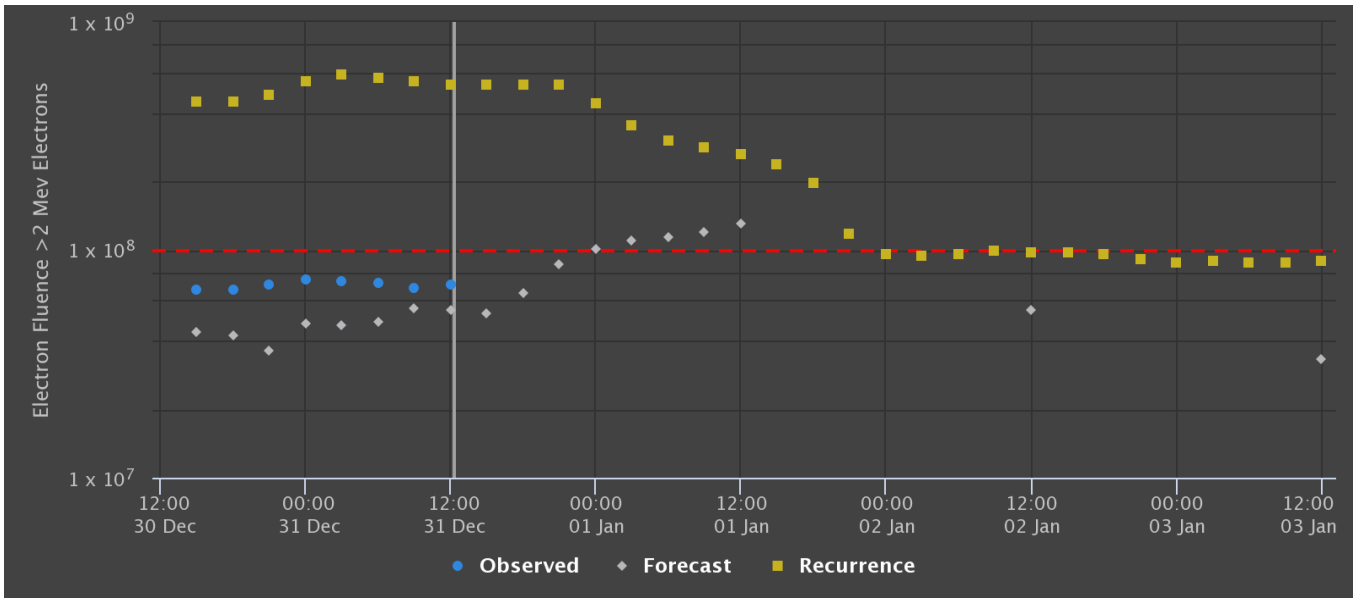
Figure 4: MOSWOC REFM latest output.



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